Magnetoresistance of a New Copolymer, $FeCl_3$ doped Poly(phenylenevinylene-co-ethylenedioxythiophene)

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Introduction

We measured magnetoresistance (MR) of the $FeCl_3$ doped copolymer in which ethylenedioxythiophene (EDOT) and phenylene are alternatively linked by vinylene unit (PPVEDOTV). This copolyer has never been synthesized before. After $FeCl_3$ doping, the high conductivity (~100 S/cm) enabled the low temperature MR measurement, which would reveal physical properties before studying proper applications. The MR showed crossover behavior from negative to positive. The temperature dependence of conductivity and MR revealed the presence of Coulomb gap (CG) in the VRH conduction.

Experimental

The electrical conductivity was measured by the DC four-probe method. Gold wires were attached by carbon paste to the $FeCl_3$ doped PPVEDOTV film and N-grease was covered to avoid exposure to air. MR was measured by sweeping magnetic field up to H=35 T using a resistive magnet in NHMFL.

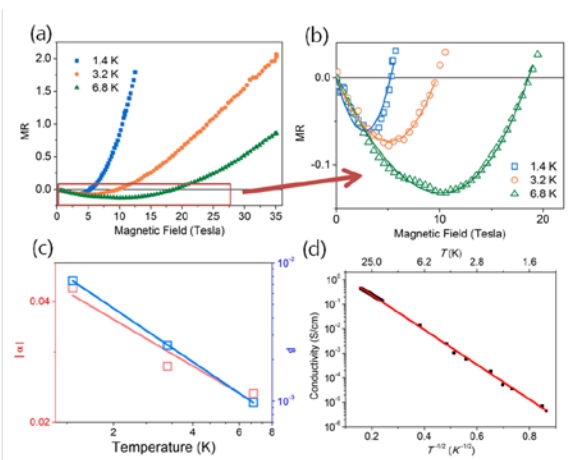

Figure 1 (a) MR of $FeCl_3$ doped PPVEDOTV. (b) Magnification of the red rectangle in (a). (c) Temperature dependence of fitting parameters α and β. (d) Temperature dependence of conductivity following CGVRH.

Results and Discussion

Figure 1 (a), (b) shows MR of the $FeCl_3$ doped PPVEDOTV film up to 35 T at fixed temperatures. At low magnetic fields, the MR was negative and crossed over to positive. The ranges of magnetic field where negative MR was observed decreased as the temperature decreased (Fig. 1 (b)). At sufficiently large magnetic fields, MR increased rapidly without saturation up to H=35 T (Fig. 1 (a)). Assuming that the observed MR is the sum of negative and positive contributions, it can be fitted by

$$[\rho(H) - \rho(0)]/\rho(0) = \alpha(T)\, H + \exp(\beta(T)\, H^2) - 1 \qquad [1]$$

, where α (*T*) and β (*T*) are negative and positive temperature-dependent constants. This is the sum of linear negative contribution of the orbital quantum interference [1] and the positive contribution due to wave function shrinkage effect [2]. Figure 1 (c) shows power law dependence of α (*T*) and β (*T*). This analysis is consistent with the Coulomb gap variable range hopping (CGVRH) behavior in Figure 1 (d).

Conclusions

We observed crossover behavior of MR from negative to positive for the $FeCl_3$ doped PPVEDOTV copolymer. The negative MR implies sufficient wave function overlap to cause quantum interference. However, at high field regime, the effect of decrease in the overlap of wave function becomes more dominant, results in high positive MR. Temperature-dependent conductivity confirms CGVRH conduction, which supports the MR analysis.

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References

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[2] Shklovskii B. I. *et al.*, Electronic properties of doped semiconductors (1984).